Regional Variability and Predictability in the Upper Ocean

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LONG-TERM GOALS

Our long term objectives are to understand the dynamics of upper ocean physical processes and air-sea exchange and to see that understanding integrated into operational Navy strategies. Of particular interest is understanding the variability of the upper ocean on vertical scales from tens of centimeters to hundreds of meters, and on horizontal scales of meters to tens of kilometers, and the role that spatial-temporal variability in the atmospheric forcing plays in setting those scales.

OBJECTIVES

Our objective for this project is to improve our understanding of variability in the upper ocean encountered by battle groups and to determine if local observations will lead to improved predictions that can be used to the advantage of Navy.

APPROACH

Our approach is to pursue our research objectives in large part by participation in fleet exercises. These exercises might include SHAREM (Ship ASW Readiness Effectiveness Measuring) Programs, MIREM (Mine Warfare Readiness Effectiveness Measuring) Programs or similar exercises focusing on the performance of Navy systems in the upper ocean and/or atmospheric boundary layer. We plan to conduct enhanced environmental monitoring during exercises. We will place small, non-intrusive instruments on ships operating in the exercise region to collect time series of the surface meteorological forcing and upper ocean structure. We will also design and fabricate easily deployable/recoverable buoys equipped with meteorological sensors and upper ocean temperature, salinity and current sensors. The marine boundary layer observations will provide complete and highly accurate air-sea flux measurements.

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Figure. Photographs showing the meteorological instrumentation being mounted on the bow mast of the R/V Gyre and of the surface buoy deployed.

These supplemental non-intrusive instruments would provide high quality in-situ measurements that would later be combined with all other data collected in stride during the exercise in an environmental reconstruction during retrospective analysis of the exercise. This retrospective analysis would focus on quantifying the environmental variability seen in the upper ocean, examining the predictability of this variability and exploring how the environment may have impacted performance of operational systems used in the exercise. We will couple our work with the SURFWARDEVEGRU (Surface Warfare Development Group) as they plan, carry out and analyze results from exercises.

WORK COMPLETED

SECNAV Oceanographic Research Chairs and ONR/Institution Scholars are asked to develop scientific collaborations with other Navy and Marine Corps activities; advise ONR on policy and procedures for support of high quality oceanographic science and technology; participate in ONR Department Reviews; help identify promising science and technology opportunities in oceanographic sciences; and participate in the synthesis of recently completed ONR initiatives. Additionally, Chairs and Scholars may be asked to represent the Navy and ONR science and technology efforts to the Fleet, other agencies, and general audiences.

This is the first year of a four year project. A large part of our effort this year went towards becoming familiar with the ONR and Navy groups and activities that we would be working with during the next three years. This included travel to various ONR and Navy meetings and workshops, as well as providing scientific briefings to distinguished visitors.

Albert Fischer is the graduate student supported on this project. Fischer is working on an analysis of data collected during the ONR Arabian Sea project studying the open ocean oceanic response to

monsoonal forcing. This project is expected to improve predictive models of the Arabian Sea. He has also been assisting with planning for future participation in Navy exercises. There are no new students entering the WHOI-MIT Joint Program this year. We are still looking for a second student and expect to find one during the next admissions cycle.

In September, we participated in GOMEX 99-2/ MIREM-9 that took place on the Texas Shelf south of Port Aransas. Our objective for this project was to assist the Surface Warfare Development Group and the Office of Naval Research in observing, documenting and improving our understanding of the marine environment encountered the during GOMEX 99-2/ MIREM 9 advanced sensors testing and operational exercises. There were two observational operations performed by the WHOI group.

The first task was to deploy meteorological instrumentation on the bow mast of the R/V Gyre. These instruments were Air-Sea Interaction and Meteorology (ASIMET) sensors. The ASIMET modules are an improved version of the IMET modules developed for the World Ocean Circulation Experiment (WOCE) program. ASIMET modules are self- powered and internally recording. These units provided continuous one minute average values. We deployed instruments to measure winds speed and direction, air temperature, relative humidity, barometric pressure, short-wave radiation and infrared radiation. These instruments were calibrated here at WHOI just prior to their deployment. They provide research quality data. When these observations are combined with a measurement of sea surface temperature, we will be able to accurately describe the surface meteorology and exchange of heat and momentum between the atmosphere and ocean in the exercise region.

The second task was to deploy an oceanographic buoy to monitor the vertical temperature and salinity (and thus sound speed) profile during the exercise. The instruments placed on the mooring were manufactured by Sea Bird Electronics, Inc. These included the SBE-39 (temperature) and SBE-37 (temperature and salinity). The sample rates for these instruments was 10 sec and 15 sec, respectively. This sample rate fully resolved all the internal wave variability. These instruments were calibrated prior to deployment. Since the R/V Gyre would be in and out of port every day, an ASIMET wind module was mounted on the buoy to provide a continuous time series of winds at the exercise site.

RESULTS

The field observations were collected from 20-27 September 1999. All instruments yielded a complete data set with the exception of the an acoustic current meter. This acoustic current meter is new and was deployed mainly to gain experience with the unit. We are uncertain why it did not record data and are currently working with the manufacturer to find the source of the malfunction. Complete raw and processed data files are available upon request.

On 21 and 22 September the winds were northeasterly ranging from 5 to 20 kts. Following the passage of a high pressure system early on 23 September, the winds became southeasterly and ranged from 2 to 15 kts. until the end of the exercise. Skies were mostly clear except for some overcast on 25 and 26 September. Seas ranged from calm to 3 to 6 ft. The air was dry and near surface humidity stayed mostly below 50%. Ocean temperatures cooled in association with the local evaporative cooling. This cooling combined with the moderate wind forcing led to near isothermal conditions in the ocean and a constant sound speed profile assumption was appropriate for the duration. There were signs of a robust nepheloid zone, 3-4 meter (10-12ft) thick, at the bottom. This is a cloudy zone that can occur when wave or current action suspends the finest clay and organic matter from the bottom sediments

and drastically reduces visibility near the bottom. Above this nepheloid zone, visibility was significantly better and ranged from 5 to 26 ft.

IMPACT/APPLICATIONS

We gave a briefing at ONR on 28 October 1999 on our observational effort and preliminary results. We gave a similar briefing to SWDG on 4 November 1999. We are in the process of putting together a report of our observations and are assisting SWDG with their environmental reconstruction of the exercise. We will continue working with SWDG and will be involved in further exercises.

At these briefings it was apparent that the physical oceanographic data can ehnance the ability to evaluate through the sensor technologies and advanced mine-hunting techniques. It was also apparent that real-time telemetry of this data, together with information on diver visibility, currents and waves, would be of help in making operational decisions (ROV and diver deployments, developing mapping strategies, etc.)

TRANSITIONS

We are coordinating with P. Jackson (SWDG) to hold a workshop on SHIREM exercises here at WHOI in early February 2000. This workshop will be attended by physical oceanographers and acoustitions from WHOI and MIT. The goal of the workshop will be to educate some of the scientists here on Navy needs for ASW. In return, the hope is that the scientific staff here can assist SWDG on devising effective monitoring plans for future SHAREMs and explore how the scientific staff may become further involved.

In this first year, we successfully collaborated with the operational navy and ONR advanced sensor groups in a MIREM exercise. We learned from the Navy and ONR investigators what sort of environmental factors play a role in performance of various systems and operations. SWDG learned what sorts of observations and analysis we can assist with in future operations. This effort is paving the way for our participation in future exercises and at a more effective level. One potential transition at the completion of this project might be the adoption of an environmental buoy, or "Battle Space Buoy", that the Navy could deploy in stride, like the Battle Space Profiler, to monitor the battle space environment in real-time during operational activities.

RELATED PROJECTS

A related project is the ONR Innovative Platforms For Upper Ocean Research (Award Number N00014-97-1-0158). The technological objectives for this project are to develop the engineering tools to model, design, build, deploy, and retrieve a reliable horizontal submerged array. This will improve our ability to fully visualize, measure, and thus understand the physical processes active in the upper ocean in three dimensions on scales from meters to one kilometer. This effort is in collaboration with M. Grosenbaugh and W. Paul from the Applied Ocean Physics department at WHOI.

1-3 December 1998	S. Anderson attends BACIMO-98 meeting at Hanscom Air Force Base.
19-20 January 1999	R. Weller visits CNMOC in Bay St. Louis, MI.
9-11 February 1999	R. Weller and S. Anderson attend Tactical Oceanography Workshop in Corpus Christi, TX.
1-6 March 1999	R. Weller participates in DOD review panel on Battlespace Environments.
26 March 1999	R. Weller and S. Anderson attend Distant Thunder briefings given at WHOI.
2 April 1999	R. Weller and S. Anderson give briefing to congressional staff member William Natter during his visit to WHOI.
23 April 1999	R. Weller gives briefing to UK Deputy Prime Minister during his visit to WHOI.
17 May 1999	S. Anderson attends ONR COAMPS review at San Francisco, CA.
1-3 June 1999	S. Anderson and R. Weller attend ONR Coupled Boundary Layers Workshop at Airlie Center in Warrenton, VA.
7 July 1999	R. Weller, S. Anderson and T. Schnoor Visit SWGD to make contacts and discuss upcoming exercises.
2 August 1999	R. Weller and S. Anderson give briefing to Oceanographer of Navy during his visit to WHOI.
23-26 August 1999	R. Weller attends ONR Optics and Mixed Layer Dynamics workshop held at the Plymouth Marine Lab, U. K.
13-30 September 1999	MIREM 99-2/GOMEX-9 Enhanced Environmental Monitoring Activities. Texas Shelf. R/V Gyre.
28 October 1999	S. Anderson and R. Weller attend GOMEX Cold Wash briefing at ONR.
4 November 1999	S. Anderson and R. Weller Visit SWDG to give briefing on MIREM Enhanced Environmental Monitoring.

Table. Chronology of project related travel and activities.